

YEHLING

Preliminary Investigations for an  
Electric Road from Gibson to Sidney

Electrical Engineering

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PRELIMINARY INVESTIGATIONS FOR AN ELECTRIC  
ROAD FROM GIBSON TO SIDNEY

BY

ALBERT CHARLES YEHLING

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

IN ELECTRICAL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

OF THE

UNIVERSITY OF ILLINOIS

Presented June, 1909

1909

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UNIVERSITY OF ILLINOIS

June 1, 1909

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

ALBERT CHARLES YEHLING

ENTITLED PRELIMINARY INVESTIGATIONS FOR AN ELECTRIC ROAD FROM

GIBSON TO SIDNEY

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

APPROVED:

*Morgan Brooks*

*Edgar Wenger*

Instructor in Charge

HEAD OF DEPARTMENT OF Electrical Engineering

145106





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## SECTION I.

## I N T R O D U C T I O N

The Wabash Railroad in Illinois consists, roughly speaking, of two main lines: the North and South, or St. Louis and Chicago, and the East and West, or Kansas City, Buffalo, New York, and Boston, divisions. These two main lines have their junction at Bement, in Piatt County, a town of fifteen hundred inhabitants. A short branch, about ten miles in length, at present extends northward from Sidney, on the main East and West line, to Champaign and Urbana, cities of population 11,000 and 7,000 respectively. Urbana is the county seat of Champaign County, and is also the location of the University of Illinois. Gibson is a town of about 2,100 inhabitants, situated almost directly north of Champaign, on the main North and South division of the Wabash system. A map ( Fig.1 ) shows the existing lines of the Wabash in Illinois, and the other railroads occupying the same section of the State.

It has been suggested that if an extension be built to the Sidney-Champaign branch, reaching from Champaign to Gibson, the Wabash would have a "short cut" from Champaign to Chicago, and should thus be able to compete with the Illinois Central for traffic northward.





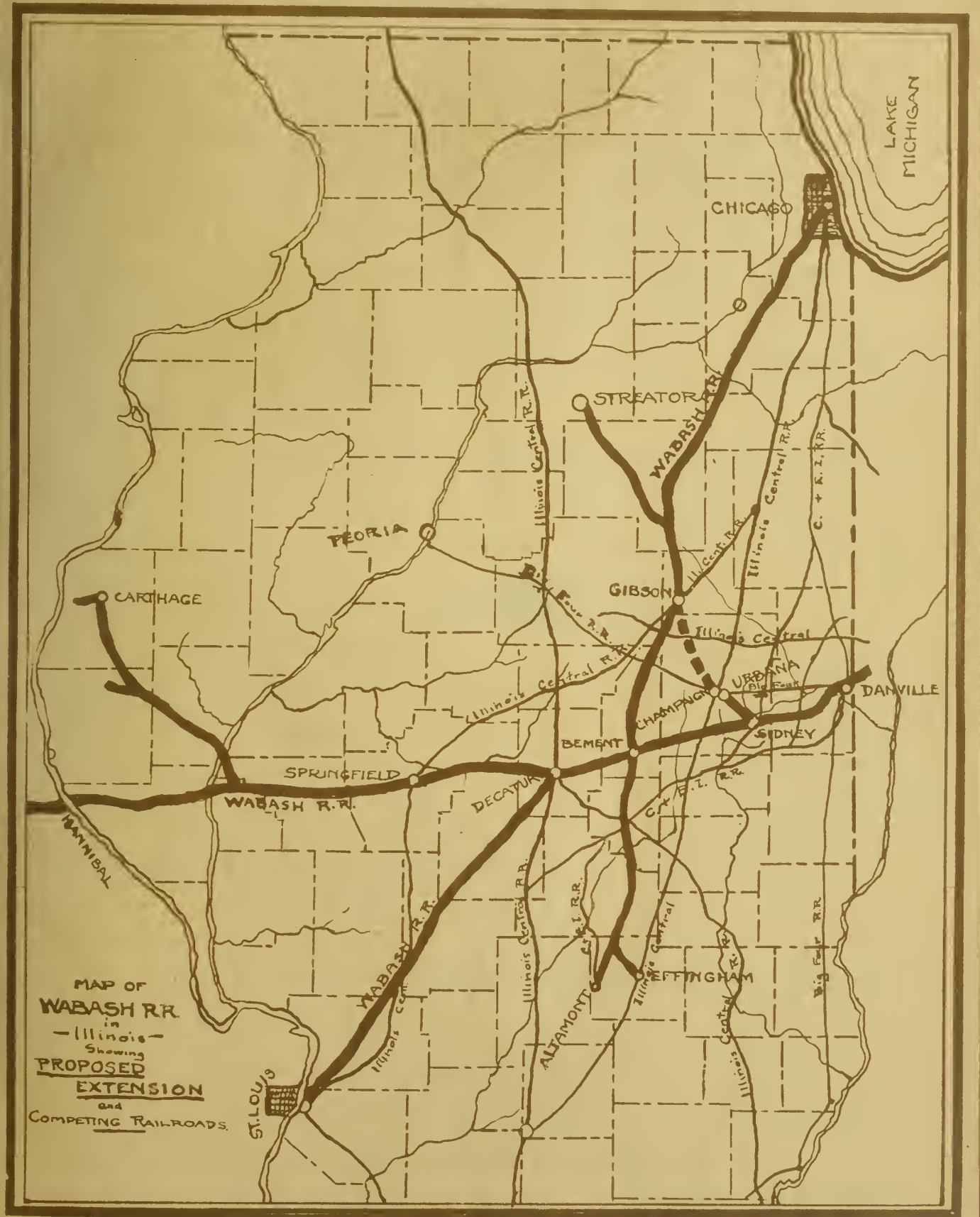


Figure 1.





## SECTION II.

## P R O J E C T

It is the purpose of this investigation to determine whether it would be feasible to extend the existing Sidney-Champaign branch of the Wabash Railroad northward, to connect with the main North and South division at Gibson. On Maps Nos. 1 and 2 are shown the route of the proposed extension, Map No.2 being a section of the Official Railroad Map of Illinois. Neighboring steam and electric roads are purpose-ly shown in detail.

This project includes the extension of the existing Sidney-Champaign branch, and the electrification of both the extension and the existing lines of track. At present the Sidney-Champaign branch is operated by steam.

The distances are:-

Present Sidney-Champaign branch.....	12 miles.
Extension, Champaign to Dewey.....	15 "
" , Dewey to Fisher.....	3 "
" , Fisher to Gibson.. .....	<u>11</u> "
Total length of <u>electrification</u> .....	41 "
" " " <u>proposed extension</u> .....	29 "

The reasons for suggesting electric instead of steam operation are as follows:-

(a) Electric passenger interurban cars and electric freight locomotives have proved successful for high speed interurban service and rapid haulage of freight trains.

(b) Power generated at a central station and transmitted electrically to motors on the axles of cars is cheaper than





Figure 2





an equivalent number of steam locomotives, each possessing its own boiler with the attendant losses.

(c) Power required for electric traction is taken by the motors only when the motors are in actual operation, while with steam there is the loss of energy due to firing up at the beginning of a run, and the waste due to the cooling down of the boiler after a run.

(d) An electric road is much more pleasant to use in travelling than is a steam road, since there is not the discomfort from dust, dirt, smoke and cinders.

(e) Wages of firemen are saved when electricity is used for propelling trains.

(f) Electric service allows frequent local stops at cross-roads and small country stations for milk cans, package freight, and passengers. Such traffic would not be worth while for a steam road, altho it amounts to considerable for an electric road.

(g) Electric power may be sold from the transmission lines for the operation of motors in farm-houses and grain-elevators.

(h) Electric power may be used for lighting the streets and residences of small towns along the route, thus giving a source of revenue apart from the actual business of railway transportation.





## SECTION III.

## T E R M I N A L S

The primary terminal of the proposed railway is the City of Champaign, with population, according to the Census of 1900, of 9,098, and estimated population for 1909 of 11,000. The City of Urbana, however, immediately adjoins Champaign on the east, the business portions of the two towns being about two miles apart. Champaign and Urbana are closely linked by an electric street railway and steam roads, so that they practically form one city. The population of Urbana in 1900 was 5,708, and estimated for 1909 at 7,000. The two towns, therefore, form a terminal with population in 1900 of 14,806, and in 1909 of approximately 18,000. This does not include the number of students attending the University of Illinois in Urbana.

The secondary terminals of the road are:-

	1900	1909
Sidney, population.....	564.....	700
Deers,               "       .....	31.....	35
Dewey,               "       .....	—.....	200
Fisher,             "       .....	614.....	800
Gibson,             "       .....	<u>2,054.....</u>	<u>3,165</u>
Secondary           "       Total.....	3,263.....	4,900
Primary Terminal   "       .....	14,806.....	18,000
Student             "       .....	<u>2,250.....</u>	<u>4,000</u>
TOTAL TERMINAL POPULATION.....	20,319.....	26,900
Terminal population per mile of track.....		658



## SECTION IV.

## T R I B U T A R Y

Tributary population is reckoned as the population occupying land within one and one-half miles on each side of the right-of-way.

	Population	Area	Population
	Total	Sq.Mi.	Per sq.mi.
Champaign County, (1900).....	47,622.....	1,008.....	47.3
Subtracting for cities.....	<u>30,000</u> .....		
Outside of cities.....	17,622.....		17.6
Ford County, (1900).....	18,250.....	580.....	31.5
Subtracting for cities.....	<u>10,000</u> .....		
Outside of cities.....	8,250.....		14.3

For  $1\frac{1}{2}$  miles on each side of the track, and 34 miles of track (exclusive of cities), the area tributary to the proposed line is 102 square miles.

Assuming tributary population at 16 per square mile,

TOTAL TRIBUTARY POPULATION..... = 1,660.





## SECTION V.

## STUDENT POPULATION

The student population in Champaign and Urbana has a peculiar effect upon traffic conditions in those towns, because:-

(a) It is the custom of most of the students to return home two or three times each year at the vacation seasons.

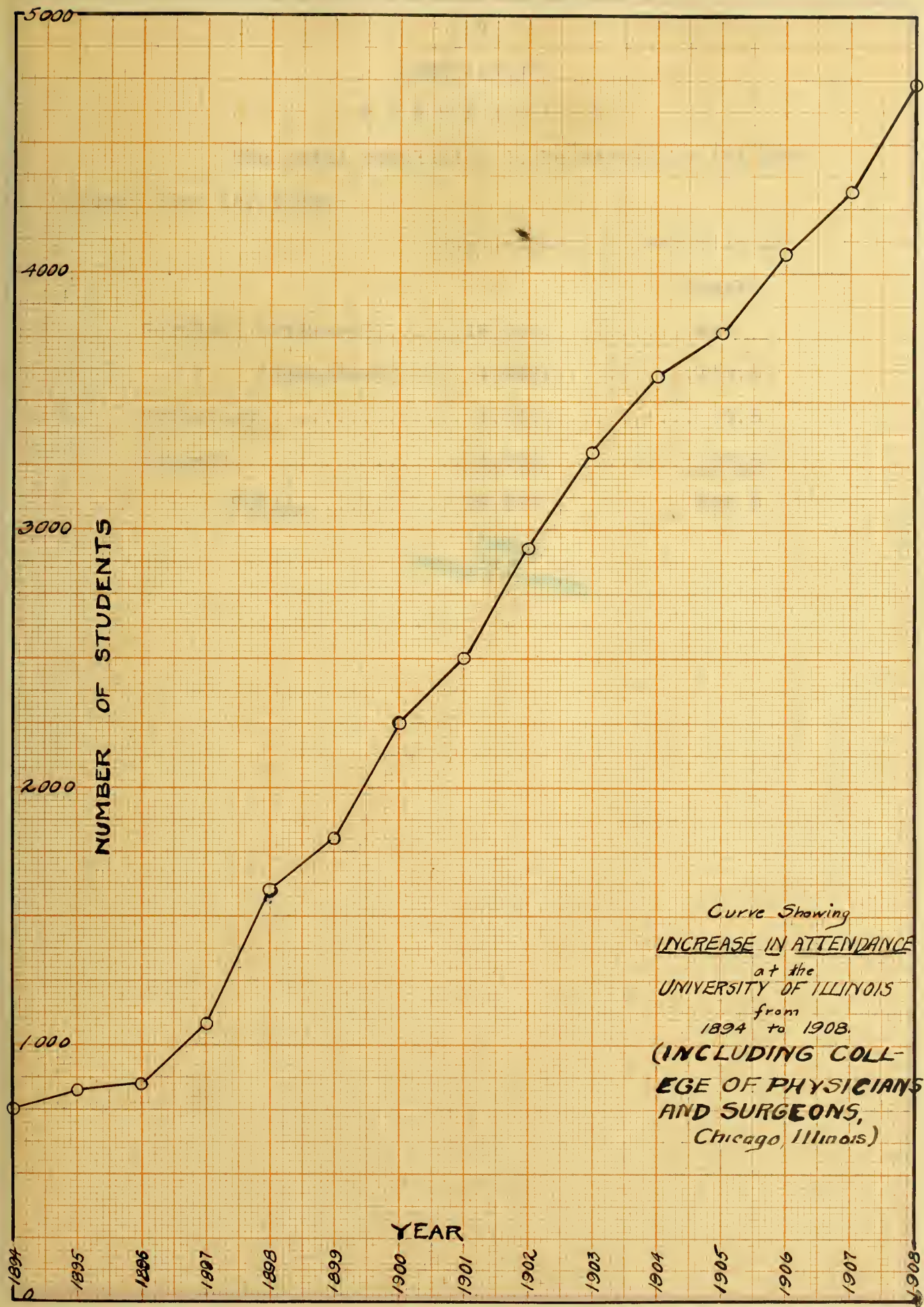
(b) Baseball and other athletic contests attract visitors from other towns, and at other times cause a large outflow of students to attend contests in other cities.

(c) Relatives and friends visit the University during Commencement and other seasons.

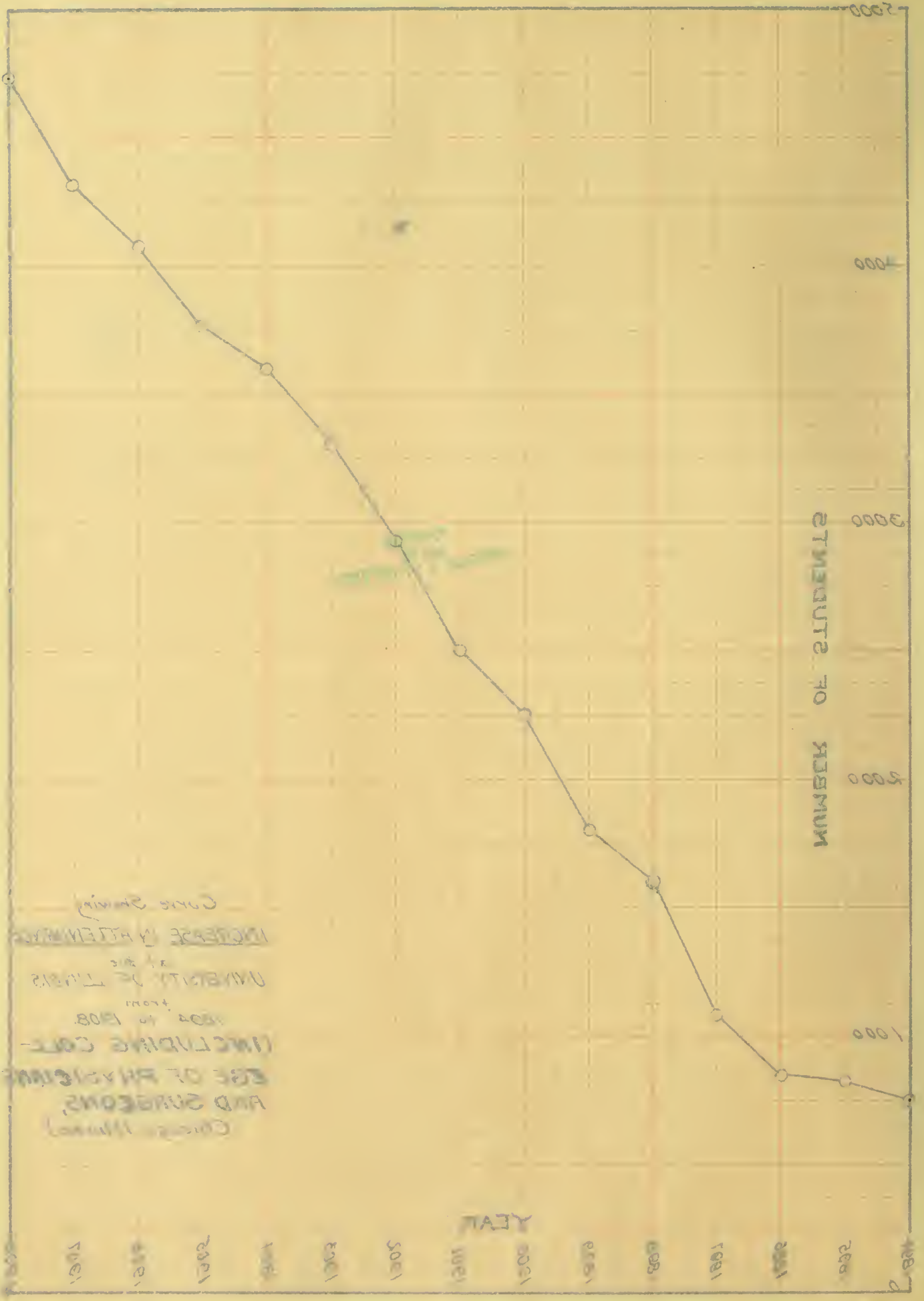
(d) Conferences and Conventions held at the University attract visitors from over the State.

Hence the effect of the student population is to cause an increase in passenger traffic greater in proportion than would be caused by an equal number of persons added to the permanent population of the Twin Cities. The magnitude and growth of the student population for several years past is shown on the curve of Fig. 7.











## SECTION VI.

## P O P U L A T I O N

The total population to be served by the proposed line is, then:-

	Population	Per mile of track
Terminal (Primary).....	18,010.....	439
" (Secondary).....	4,908.....	119.5
Tributary.....	1,860.....	40.5
Student.....	<u>4,000.....</u>	<u>97.5</u>
<u>TOTAL.....</u>	28,568	696.5



## SECTION VII.

## I N D U S T R I E S

Champaign and Urbana:-

Champaign and Urbana are primarily University towns, and they possess only small factories. The industries include:

Foundries.....	2
Planing Mills.....	3
Lumber Yards.....	3
Marble Works.....	1
Piano Factory.....	1
Farm Machinery, Factory.....	1
Buggies and Wagons, " .....	1
Dairies.....	3
Railroad Shops.....	2
Gas and Electric Plant.....	1
Bottling Works.....	2
Harness Factory.....	1
Mattress Factory.....	1

The value of the manufactures of Champaign, as given by the United States Census of 1900, was \$486,229, the city being 31st in order among the cities of the State.

Gibson City:-

The industries of Gibson include:

Iron Works.....	1
Canning Factory.....	1
Shoe Factory.....	1
Tile Factory.....	1





## SECTION VIII.

## P R O D U C T I O N .

The two counties traversed by the proposed line, Champaign, and Ford, lie in the heart of the Illinois corn fields, Champaign County holding the world's record for corn production. Data has not been procured concerning the amount of corn produced by these Counties in the last year. However, from figures given in the 1906 Yearbook of the Department of Agriculture an estimate of the production has been made:-

Assuming two-thirds of the County set in corn, and a production of 40 bushels per acre, the annual yield for Champaign County becomes

$\frac{2}{3} \times 1,008 \times 640 \times 40 = 17,203,200$  bushels  
with a value of approximately \$5,500,000.

Ford County is about one-half as large as Champaign County, hence, according to this estimate its production should be

$\frac{1}{2} \times 17,203,200 = 8,601,600$  bushels,  
with a value of approximately \$2,750,000.



## SECTION IX.

## P R E S E N T   R A I L R O A D   F A C I L I T I E S

A very large proportion of the student and other travel from Champaign is to Chicago. This traffic is now almost entirely served by the Illinois Central Railroad north from Champaign, and the Chicago and Eastern Illinois Railroad north from Glover. ( Glover is a small station about ten miles east of Champaign, and is reached by the Big Four Railroad and the interurban lines of the Illinois Traction System.) The Wabash Railroad at present enjoys very little of this great amount of passenger traffic into and out of Champaign, since its facilities for passenger accommodations to Chicago are very poor. To get to Chicago over the Wabash now requires going south to Sidney, west to Bement, then north to Chicago, the shortest time required being six hours. ,

The Big Four Railroad offers competition for traffic east and west, altho the Wabash now secures its share of passengers to St. Louis. Many of the passengers to St. Louis now take the electric interurban cars of the Illinois Traction System to Bement or to Decatur, then go south on the Wabash Railroad.

One of the great inconveniences of the present railroad service from Champaign is that the accommodations to Chicago about mid-day are very poor. A local train now leaves Champaign over the Illinois Central at 1:20 P.M., arriving in Chicago at 5:20 P.M., a trip of four hours. A train on the Chicago and Eastern Illinois leaves Glover at





1:36 P.M., arriving in Chicago at 5:01 P.M. In order to take this Chicago and Eastern Illinois train at Glover one must leave Champaign on the 12:30 P.M. Interurban car, thus making the time to Chicago four hours and thirty-one minutes.

The Wabash Railroad now runs a train north from St. Louis to Chicago, which leaves Gibson at 1:14 P.M., arriving in Chicago at 4:58 P.M.. With the proposed extension it would be possible to make connections with that train by travelling the twenty-nine miles from Champaign to Gibson in forty minutes, that is, with departure from Champaign at 12:30 P.M., the same time as for the present connection over the Chicago and Eastern Illinois Railroad. The time of arrival in Chicago would be practically the same as with the Chicago and Eastern Illinois, and twenty-two minutes earlier than with the Illinois Central Railroad. The Wabash, with an attractive high-speed electric car to Gibson, and offering Pullman service from Gibson to Chicago should prove a pleasant alternative to the tiresome local service of the Illinois Central Railroad, and could compete favorably with the Chicago and Eastern Illinois.

Another very good connection could be made with a Wabash Railroad train, leaving Chicago at 12:04 P.M., arriving at Gibson at 3:14 P.M., thence to Champaign at 3:54 P.M.. This would give persons time enough to do some business in Chicago in the morning, and still get to Champaign in the afternoon. The only present connection from Chicago in the afternoon is one by way of the Chicago and Eastern Illinois Railroad to Danville, then over on the



Interurban, arriving in Champaign at 5:25 P.M..

The distances and fares to Chicago over these three roads are as follows:-

	Miles	Fare
Illinois Central.....	128	\$2.56
Chicago and Eastern Illinois (via Glover).....	140	\$2.80
Proposed Wabash.....	138	\$2.76

It has been stated that it would be possible to make the run from Champaign to Gibson in forty minutes, to make connections there with the 1:14 P.M. train. To prove this statement:-

Let it be assumed that there are stops of one minute each at Fisher and Dewey. Then

Total time, Champaign to Gibson.....=40 minutes  
 Stop, Dewey.....= 1 minute  
 Stop, Fisher.....= 1 minute  
 Running time, 29 miles.....=38 minutes.

Assuming acceleration of  $1\frac{1}{2}$  mi./ hr./ sec. at starting of car, and same for negative acceleration due to braking for a stop, with assumed running speed of 45 miles per hour,

We get:-

Time to acquire speed of 45 mi./ hr. from a standstill or vice versa =  $\frac{45 \text{ mi./hr.}}{1\frac{1}{2} \text{ mi./hr./sec.}} = 30 \text{ seconds.}$

Total number of successive accelerations and retardations between Champaign and Gibson = 6.

(Stops at Dewey, Fisher, Gibson; starts at Champaign, Dewey, Fisher.)



Hence, total time required for accelerations and braking  
 $= 6 \times 30 \text{ seconds} = 180 \text{ seconds} = 3 \text{ minutes}.$

Considering the acceleration uniform in each case between standstill and full speed, we may assume that for those three minutes the car is running at a uniform rate, which is the average between standstill and 45 miles per hour, or  $22\frac{1}{2}$  miles per hour. For those three minutes, therefore, the car has been running at only one-half speed, or at a sacrifice of  $1\frac{1}{2}$  minutes. The actual running time at normal speed for the 29 miles would thus be reduced to  $38 - 1\frac{1}{2} = 36\frac{1}{2}$  minutes. The maximum speed required, therefore becomes:-

$$60 \div \frac{36.5}{29} = 47.6 \text{ miles per hour.}$$

The average speed, including stops, is:-

$$60 \div \frac{40}{29} = 43.5 \text{ miles per hour.}$$

With the use of sixty-mile-per-hour interurban cars this time could be made with ease. It is seen that four minutes have been allowed for connections at Gibson.

Altogether the Wabash Railroad has four through trains each way daily between Chicago and St. Louis, and the proposed extension would offer that much greater range of available routes and connections south to and north from Champaign and Urbana.

The cities of Pontiac, Streator, and Joliet are very easily reached by the Wabash Railroad, whereas with the other roads one must go to Chicago, then double back.

Even with the proposed extension the Wabash Railroad could not hope to compete in a straightaway run





with the fastest schedule maintained over the Illinois Central Railroad---three hours and ten minutes---, because the Illinois Central track is almost perfectly straight most of the way from Champaign to Chicago.

783.3  
gBlam

## SECTION X.

## P R O B A B L E    E A R N I N G S

A.-THROUGH PASSENGER TRAFFIC:-

Through passenger traffic will be taken as meaning the passenger traffic extending beyond the limits of the proposed extension, as opposed to local interurban traffic.

Considerable difficulty has been experienced in obtaining data on the ticket sales at the railroad offices in Champaign and Urbana. From such data as has been obtained, charts (Fig.3) have been drawn, showing the approximate monthly sales at each of the railroad offices in the two towns. The sales at the Illinois Central office for one year have been taken at \$168,000. The average monthly sales at the Big Four Railroad offices have been taken at \$6,000 in Champaign, and \$4,000 in Urbana.

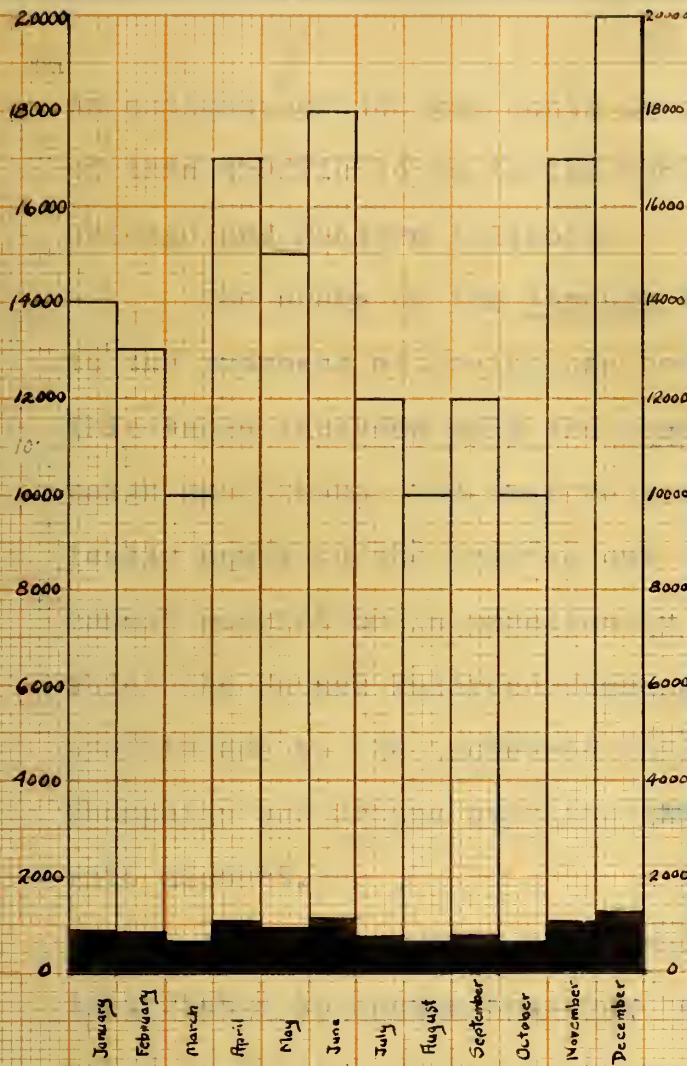
In the calculations made for probable ticket sales it is assumed that the Wabash extension will secure one-eighth of the traffic now carried by the Illinois Central Railroad northward. The total Illinois Central sales are considered as being divided, one-half for northbound tickets and one-half for southbound tickets. The Wabash Railroad cannot compete for the southbound sales. In competition with the Big Four Railroad for traffic East and West, the assumption is made that the Wabash will secure one-fourth of the Champaign and Urbana traffic.

The Illinois Traction System gives as its number of tickets from Champaign to Glover as 64 per month, and from Urbana as 150 per month, making a total of 214 per month.

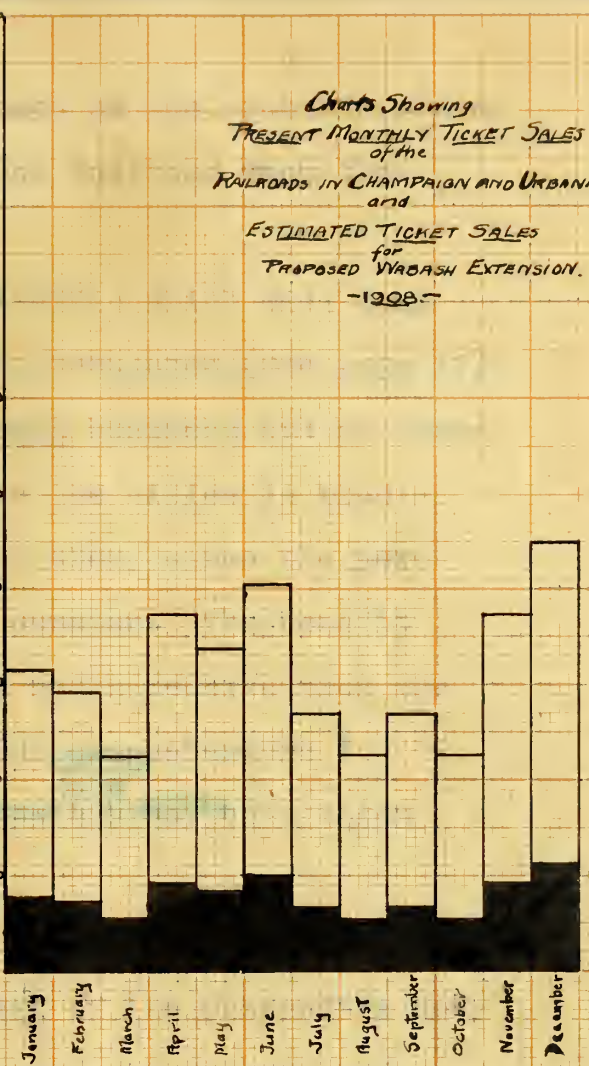




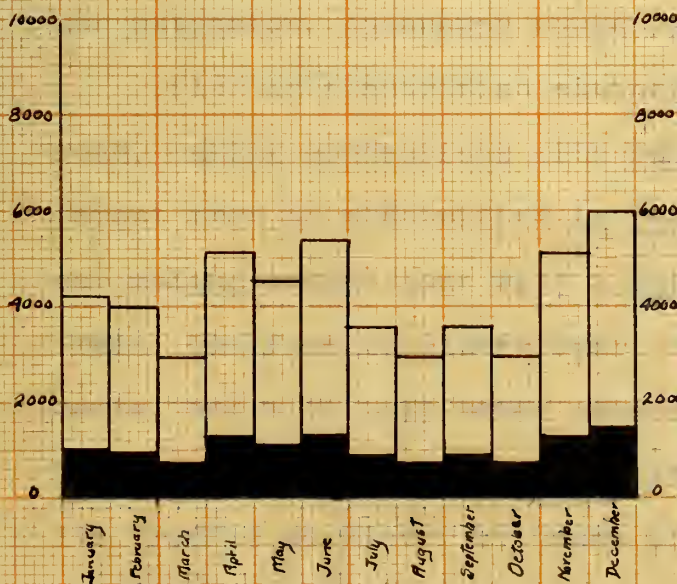
Charts Showing  
PRESENT MONTHLY TICKET SALES  
 of the  
RAILROADS IN CHAMPAIGN AND URBANA  
 and  
ESTIMATED TICKET SALES  
 for  
PROPOSED WABASH EXTENSION.  
 -1908-



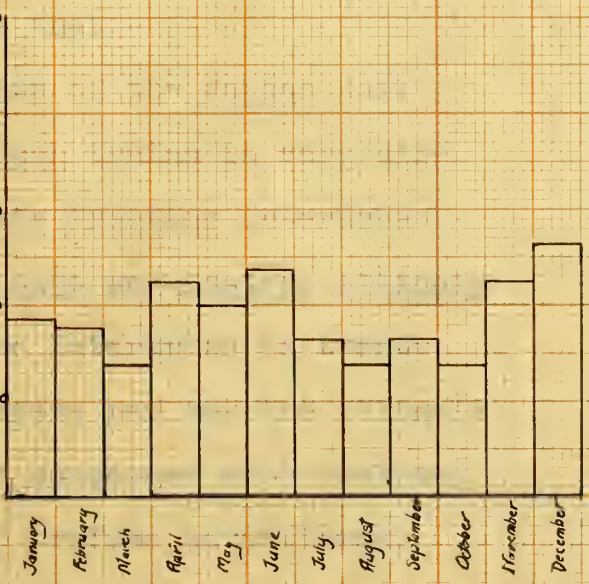
ILLINOIS CENTRAL  
 Share to Wabash ■



BIG FOUR (Champaign)  
 Share to Wabash ■



BIG FOUR (Urbana)  
 Share to Wabash ■



ESTIMATED SHARE OF  
WABASH. (Champaign and Urbana)

Figure 3.

८ ७-१०१३





An estimate of 100 per month is made as the probable share of this traffic to go to the Wabash Railroad from the Chicago and Eastern Illinois.

The share of the through traffic which will come to the proposed extension has been tabulated. (See page 17.) This table includes only the through business out of Champaign and Urbana. The traffic into the cities is practically equal to the traffic out of them, since the permanent population is practically constant. The benefit which the Wabash Railroad Company would receive from the traffic due to the increased influx of passengers to Champaign and Urbana over its lines has not been taken into account.

A question might be raised as to whether it is justifiable to assume that one-half of the passengers now going to Chicago by way of Glover and the Chicago and Eastern Illinois Railroad, and one-eighth of the present Illinois Central northbound passengers will take the Wabash extension. An answer would be that:-

(1) An electrified extension of the Wabash Railroad, making connections with Wabash trains is very different from an electrified Illinois Traction interurban car making connections with a Chicago and Eastern Illinois train. The fare to Glover over the Interurban is twenty cents, and with only seven passengers per day the Illinois Traction System cannot be greatly concerned with swelling its traffic to Glover by means of profuse advertising.



MONTH	ILLINOIS CENTRAL Total	ILLINOIS CENTRAL North- bound	SHARE TO WABASH 1/5 of North- bound Illinois Central	BIG FOUR Champaign Total.	SHARE TO WABASH 1/4 of Big Four in Champaign	BIG FOUR Urbana Total	SHARE TO WABASH 1/4 of Big Four in Urbana	SHARE TO WABASH From C+E.I. at 100 per month	TOTAL SHARE TO WABASH from Champaign and Urbana
January	\$ 14,000	\$ 7,000	\$ 875.	\$ 6,300	\$ 1,575.	\$ 4,160.	\$ 1,040.	\$ 276.	\$ 3,766.
February	13,000	6,500	812.50	5,850	1,462.50	3,920	980.	276.	3,531.
March	10,000	5,000	625.	4,500	1,125.	2,960	740.	276.	2,766
April	17,000	8,500	1062.50	7,500	1,875.	5,130	1282.50	276.	4,496.
May	15,000	7,500	937.50	6,750	1,687.50	4,490	1,122.50	276.	4,023.50
June	18,000	9,000	1,125.	8,100	2,025.	5,570	1,342.50	276.	4,768.50
July	12,000	6,000	750.	5,400	1,350.	3,600	900.	276.	3,276.
August	10,000	5,000	625.	4,500	1,125.	2,960	740.	276.	2,766.
September	12,000	6,000	750.	5,400	1,350.	3,600	900.	276.	3,276.
October	10,000	5,000	625.	4,500	1,125.	2,960	740.	276.	2,766.
November	17,000	8,500	1062.50	7,500	1,875.	5,130	1,282.50	276.	4,496.
December	20,000	10,000	1250.	9,000	2,250.	6,000	1,500.	276.	5,276
For Year	\$ 168,000.	\$ 84,000	\$ 10,600.	\$ 75,300	\$ 18,825	\$ 50,280.	\$ 12,570.	\$ 3,612.	\$ 45,607.

Table showing estimated

TICKET SALES

at  
RAILROAD OFFICES IN THE  
TWIN CITIES

PROBABLE SHARE TO PROPOSED EXTENSION —





With a Wabash extension, with ability to sell tickets to points on the main Wabash line, it would be appropriate for the Wabash Railroad to see that its trains are well advertised.

(2) There would not be the necessity of buying tickets again at the junction point, Gibson, so that much of the delay and inconvenience of changing cars as at Glover would be eliminated. It might be feasible to haul a passenger coach over the electric line, with possibility of attaching it directly to the steam train at the junction, thus doing away with even the necessity of changing cars.

#### B.-LOCAL PASSENGER TRAFFIC:-

The total terminal and tributary population is estimated in Section VI at 28,568.

Assuming an income of \$5.00 per capita per year we obtain:-

Income per year =  $28,568 \times \$5.00 = \$142,840$ .

Income per year per mile of track = \$3,484.

To determine whether this estimate is correct, let it be compared with the earnings of other roads in actual operation:-



#	Company	Length of line	Earnings per mile
		Miles	of track
1. -----		145	\$3,812
2. -----		134	\$3,336
3. -----		83.5	\$2,453
4. -----		52.0	\$3,023
5. -----		39.0	\$4,910
6. -----		30.0	\$3,543
7. -----		20.2	\$3,533
8. -----		17.0	\$2,886
9. Proposed Wabash		41.0	\$3,484

It is evident from this table that the estimate of \$3,484 per mile of track is not excessive. The proposed line is, however, somewhat unusual, because the principal terminals are located at the middle of the length, and not at the ends. In order to leave a sufficient margin of safety in this case, let it be assumed that the earnings will be very low, say, \$2,500 per year per mile of track. Whence:-

Income from local passenger traffic per year =

$$41 \times \$2,500 = \underline{\underline{\$102,500.}}$$

# Lecture, Prof. Harding of Purdue University.





### C.--PRESENT WABASH PASSENGER TRAFFIC:--

Estimates have been made under (A) of this section, on the East and West traffic to be secured by the proposed extension in competition with the Big Four Railroad, and under (B), on the local traffic between Urbana and Sidney. It will be considered, therefore, that the present volume of Wabash traffic is accounted for in those estimates.

### D.--FREIGHT TRAFFIC:--

The freight now brought into Champaign and Urbana is in amount as follows:--

	Present		Proposed	
	Volume		Extension	
	Champaign	Urbana	Champaign	Urbana
Wabash,	cars, 2	1	2	1
Illinois Central "	8	---	6	0
(from north)				
Big Four	" 3	2	1	0
Illinois Traction"	<u>1</u>	<u>0</u>	<u>---</u>	<u>---</u>
System	<u>14</u>	<u>3</u>	<u>9</u>	<u>1</u>

Assuming tonnage per car = 20 tons, freight coming to the proposed extension per day becomes:--

	<u>Cars</u>	<u>Tons</u>	<u>Miles</u>	<u>Ton-miles</u>
Present Wabash,				
Sidney to Champaign	2	40	12	480



	Cars	Tons	Miles	Ton-miles
Sidney to Urbana	1	20	10	200
From Illinois Central (Gibson to Champaign)	6	120	29	3480
From Big Four (Sidney to Urbana)	<u>1</u>	<u>20</u>	<u>10</u>	<u>200</u>
	10	200	61	4360

Assuming earnings from freight haulage at  $\frac{3}{4}$  cent per ton-mile, #

Total income from import freight per year =

$$4360 \times \$ .0075 \times 300 = \$9760.$$

The export freight from Champaign and Urbana is small in amount, because the towns are not manufacturing centers. Let it be assumed, then, that one car per day is shipped out of Champaign and Urbana northward, as traffic over the Wabash Railroad, and that the distance is 30 miles. Then, assuming earnings as  $\frac{3}{4}$  cent per ton-mile as with import freight,

Total earnings per year from export freight =

$$20 \times 30 \times \$ .0075 \times 300 = \$1350.$$

Hence,

Earnings from import freight.....\$9760.

Earnings from export freight.....\$1350.

Gross freight earnings per year , estimated, \$11,110

#### E.-SALE OF POWER:-

The power sold will be used for operating motors in grain elevators, and for lighting the streets

# "American Railway Transportation."-- Johnson.



and residences of Sidney and Fisher. Trolley voltage is subject to great fluctation, hence motors cannot be run satisfactorily by taking current directly from the trolley circuit. Installation of induction motors is expensive, hence impracticable except at Sidney and Fisher, and the motor load will therefore be confined to those two towns.

Power delivered in Sidney or Fisher, (estimated maximum of 20 K.W. ) per day,  
K.W. hrs. load

Factor  
20 X 24 X .20 = 96 K.W. hours.

Average return per K.W. hour (estimated)=.10

" cost " " " " =\$.05

Net earnings " " " " ...\$.05

Net yearly return from sale of power in the

two towns =

towns K.W.hrs. days return

2 X 96 X 365 X \$.05 = \$3,510.





## P R O B A B L E   E A R N I N G S

F.-SUMMARY:-

SOURCE	ANNUAL TOTAL EARNINGS	EARNINGS per mile of track
"Through" passenger traffic.....	\$ 45,607	\$1,110.
Local passenger traffic.....	102,500	2,500.
Export freight.....	1,350	32.90
Import freight.....	9,760	238.
Sale of power.....	<u>3,510</u>	<u>85.60</u>
<u>GRAND TOTAL.....</u>	<u>\$162,727</u>	<u>\$3,966.50</u>



## SECTION XI.

## P R O B A B L E   C O S T

A. --TYPE OF INSTALLATION:--

## (1) -- General:--

It is necessary to determine the general type of installation before estimates on probable cost of the extension can be made. The project includes:--

a. Electrification of twelve miles of track existing between Champaign and Sidney.

b. Building of a new electrified extension from Champaign to Gibson.

A profile map, (Fig. 3), shows that there are no great engineering difficulties to be met, for the new section is almost level for the entire distance. Two small bridges will be required, one between Dewey and Fisher, and one between Fisher and Gibson.

It has been decided to go through Dewey, altho that will make the track longer, because the local traffic from a small town is considerable.

Length of new track.....	=29 miles
"        " existing track.....	= <u>12</u> "
Total length of road .....	41        "

The existing track between Sidney and Champaign is in fair condition, and all that will be required on that division will be the bonding of the rails and the stringing the overhead work---- the trolley-wire and high-tension transmission lines.

## (2)---High tension transmission system:--





The usual practice in power transmission work is to consider 1000 volts per mile a good trial value. Hence, for this case, with 41 miles,

Transmission voltage =  $41 \times 1000 = 41000$  volts.

This voltage, however, is not standard; therefore, in order to use standard transformers and other standard apparatus which will be less expensive than specially constructed 41000 volt equipment, it is decided to use standard 33000-volt transmission. Two systems of such transmission are available: 33000-volt single phase, and 33000-volt three phase. The relative costs for these two systems are:- #

Cost per mile, three phase = \$1,637.

" " " , single " = \$1,125.

Difference for " " = \$ 512. per mile.

If it be considered that machines bought from manufacturers will almost always be wound three-phase, and that the purchaser will pay for three-phase machines in either case; that induction motors may be run off a three-phase circuit; that the load may be equally divided between phases to give good regulation; and that if one phase of a three-phase system becomes disabled the other two phases will carry the load (with delta connection, or with grounded neutral in a Y-connection) !, it is seen that a three-phase system is preferable to a single-phase system in spite of its higher cost of installation.

The frequency to be used will be taken as standard

# Standard Handbook for Electrical Engineers, Sect. 13.

! Elements of Electrical Engineering. Steinmetz.



25 cycles.

(3)---Distributing system:--

Several methods of getting current to the cars are available. The maximum amount of power which can be taken by a locomotive or a car from a direct current trolley wire at 600 volts is about 300 horse-power. The locomotives required for the proposed road need not be of more than 300 horse-power capacity, nor the passenger interurban cars of more than 200 horse-power. A third-rail system, therefore, will not be considered, since the cost would be excessive, and such a system will not be required. Following are the comparative costs of various installations:--

A.C.-- 6,600-11,000 volts,	per mile, \$3,230.
D.C.-- 600 volts, span construction,	" " , \$3,326.
D.C. --600 volts, bracket " , " " ,	\$2,497.
D.C.-- 600 volts, catenary " , " " ,	\$2,681.

Of these systems, the 600 volt, direct current, catenary trolley construction possesses the advantages of low cost of installation and maintenance, and the level trolley wire of the catenary method of suspension. It will be selected for the proposed road. Catenary construction offers a lower cost of maintenance because the trolley pole is not liable to "pound", due to unevenness of the wire, and therefore hangers and cars are not worn out quickly, as is the case with the bracket construction, which has a lower initial cost of installation.

(4)---Sub-stations:--

The general practice of interurban roads is to  
 Standard Handbook for Electrical Engineers.



place their sub-stations about ten miles apart. The map (Fig.2) shows that we may place our sub-stations at the natural division points: Sidney, Champaign, Dewey, and Gibson City, the lengths of divisions being 12, 15, and 14 miles. The high-tension transmission line must pass around the cities of Champaign and Urbana, so that a sub-station located at Champaign would be at the northern edge of the city. The lengths between sub-stations would then become approximately 13, 14, and 14 miles, making a very nearly equal division.

It may be suggested that the line might be operated with one phase of the three-phase transmission on each of the three divisions, giving balanced load and good regulation.

(5)---Power Plant:--

The best location for the power plant seems to be at Sidney, Illinois. The reasons are:--

a. Condenser water may be secured in sufficient quantities from a branch of the Salt fork stream, which passes about one hundred feet east of the Wabash Station at Sidney.

b. Coal facilities are good, since the plant would be located on the main line of the Wabash Railroad, and there are coal mines on the Wabash about twenty miles east.

c. There is sufficient space available to allow building of car-barns adjoining the power plant, and the land would be comparatively cheap.

It would be possible to dam up the stream mentioned to get a reserve supply of water if necessary, since the present Wabash main line runs along the crest of a 25-foot





embankment and across a bridge over the stream. Also, if the power plant be built next to the embankment, coal could be unloaded by gravity from the cars into the coal bunkers.

#### B. COST OF INSTALLATION:--

The type of installation selected closely corresponds with that in actual operation by the Illinois Traction System in the same neighborhood. Hence some of the items of cost given below have been obtained from them; other costs are from the Standard Handbook for Electrical Engineers, and from figures given by Professor Harding of Purdue University.

Cost of 33000 volt, 3-phase transmission line, Sidney to Gibson, 41 miles at \$1,637 per mile.....	\$ 67,117
Trolley construction, catenary, 600 volts, d.c., 41 miles at \$2,681 per mile.....	\$109,921
Bonds, 41 miles at \$600 per mile.....	\$ 24,600
New roadbed, Champaign to Gibson, 29 miles at \$15,000 per mile.....	\$435,000
Repairs on existing roadbed, Sidney to Champaign, 12 miles at \$500 per mile.....	\$ 6,000
Sub-stations and equipment, Champaign, Dewey, Gibson, 3 at \$15,000 each.....	\$ 45,000
Sub-station, located in power house at Sidney, equipment.....	\$ 14,000
Sub-station at Fisher, for street lighting,	



building and equipment.....	\$ 10,000
Power Station,	
41 miles at \$2,450 per mile.....	\$100,450
Cars and equipment,	
41 miles at \$1,500 per mile.....	\$ 61,500
Telephone line,	
41 miles at \$120 per mile.....	\$ 4,920
Right-of-way, Champaign to Gibson, land at	
\$200 per acre, 50 feet wide, 29 miles.....	\$ 35,151
Car-barn, and land occupied by it and Power	
Station, estimated.....	<u>\$ 15,000</u>
<u>TOTAL INITIAL COST OF IMPROVEMENTS AND EXTENSION</u>	
	<u>.....\$928,659</u>

(Freight and ticket offices are assumed to be included  
in the sub-station buildings.)

To get initial cost of existing Sidney-Champaign  
branch of the Wabash Railroad:-

12 miles roadbed, at \$15,000 per mile.....	\$180,000
Right-of-way, assuming land at \$100 per acre at the time	
of building that branch, 50 feet wide, 12 miles	
	.....\$ 7,686
Roadbed and switching yards at terminals,	
1 mile at \$15,000.....	\$ 15,000
Assume cost of land for freight yards and	
Passenger stations at Champaign and Urbana....	\$ 25,000





Then,

<u>TOTAL ORIGINAL INVESTMENT</u> .....	= \$227,686.
<u>TOTAL ADDITIONAL INVESTMENT</u> .....	= \$928,659.
<u>TOTAL INVESTMENT</u> .....	= \$1,156,345.
TOTAL INVESTMENT PER MILE OF TRACK.....	= \$28,200.



## SECTION XII.

## ANNUAL OPERATING EXPENSES

A sample train-sheet, showing running schedules suggested for cars, is shown (Fig.4) . From this train-sheet a curve, (Fig.5), has been plotted to show the approximate load, or ampere output, required of the generating station at different hours of the day. This curve has been compiled from data given in Wilson and Lydall, "Electric Traction". The assumptions are that a 100 H.P. motor will take at the moment of starting, 185 amperes, which current decreases in about 45 seconds to a normal value of 80 amperes for a uniform speed of 45 feet per second ( $37\frac{1}{2}$  miles per hour). The cars are assumed to be equipped each with two 100 H.P. motors, or four 75 H.P. motors. Knowing the exact number of cars starting, stopping, or running at normal speed at successive moments, it was possible to plot the curve shown.

There are momentary currents at about 3:45 P.M. and 6:00 P.M. of over 1200 amperes; but machines of lower capacity can stand a rush of current of 1200 amperes momentarily without harm. About 550 amperes seems a fair estimate for machines to be used in the present case. This indicates an output of

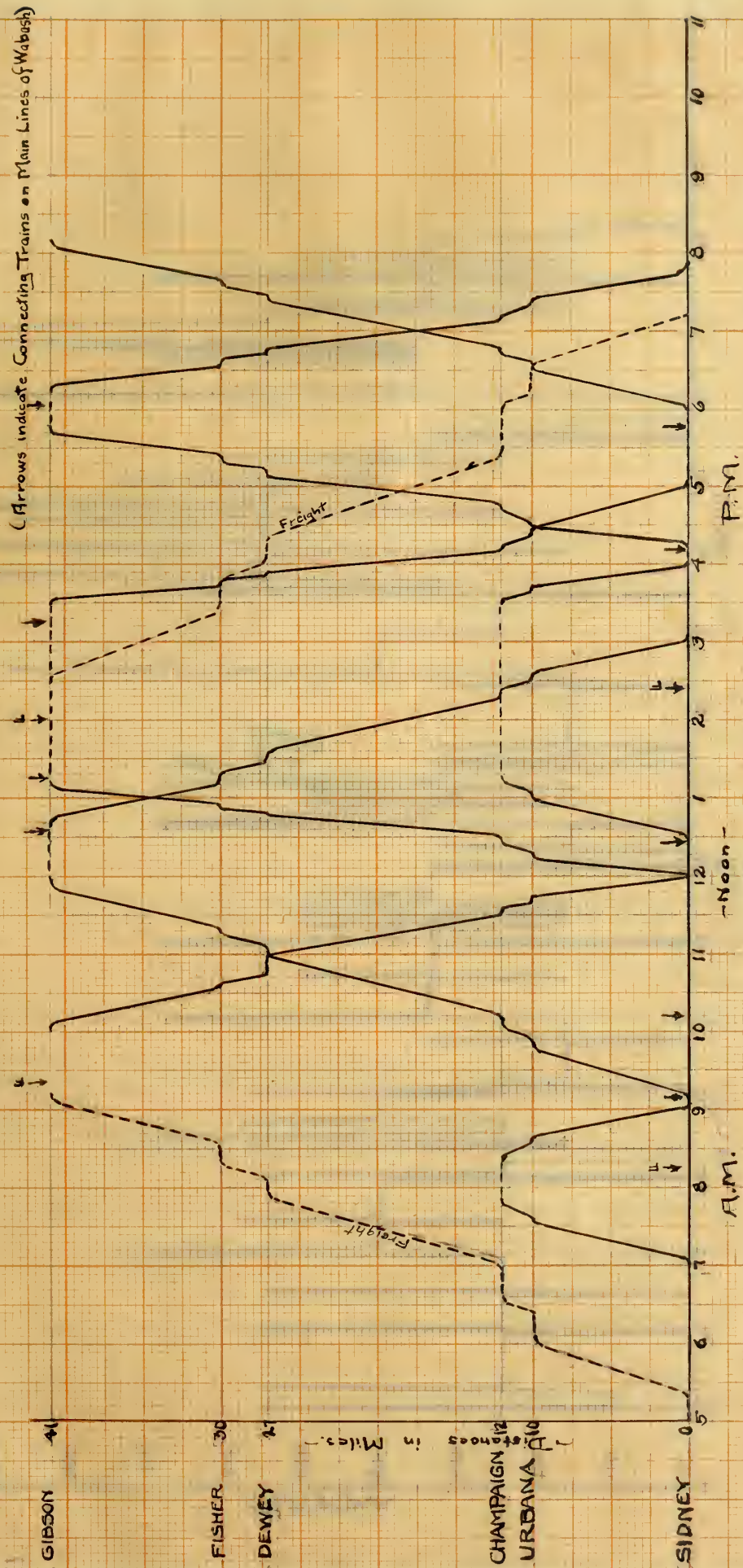
$$550 \times 600 = 33,000 \text{ watts} = \underline{330 \text{ K.W.}}$$

In order to allow for future growth, let it be assumed that generators to supply 400 K.W. to the motors will be installed. The Illinois Traction Company, in the same neighborhood claims that it generates power at a cost of from .5 to 1.0 cent per K.W. hour. Let it be assumed that the power generated in this station will cost 1 cent per K.W. hour.

Then:







Sample Daily Train-Sheet For The  
Proposed Extension.

Figure 4.



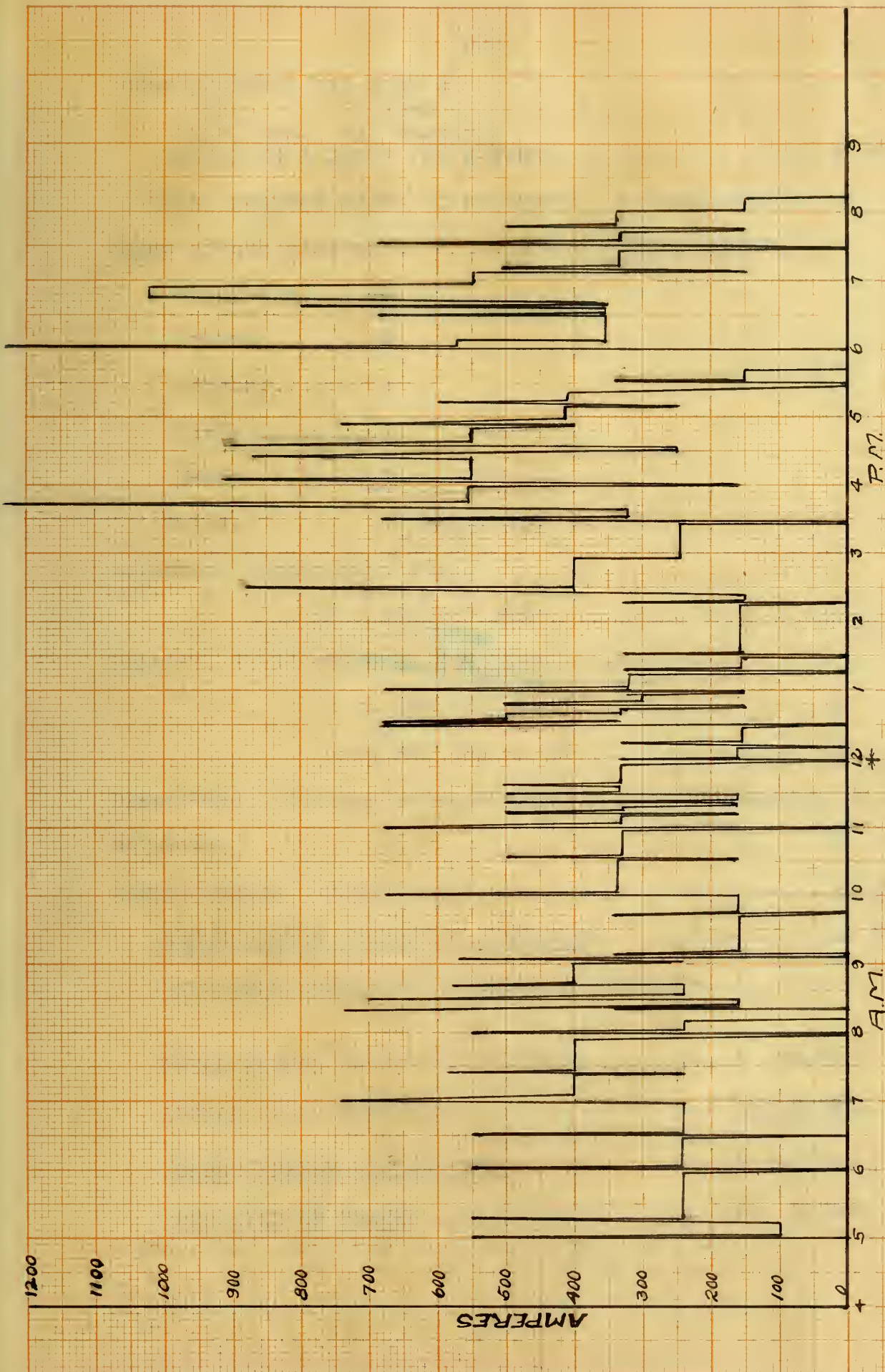
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TIME OF DAY  
ESTIMATED LOAD CURVE.  
(Not including Lighting Circuits)

Figure 5



# 3-AMINO-2-NAPHTHOL SULFONATE (Cationic dyes and related compounds)

Time 10 min



## COST OF POWER PER YEAR =

load  
 K.W. hr. da. factor  
 400 X 24 X 365 X .50 X \$.01 .....\$ 17,500

( This includes wages of engineers, firemen, etc. )

Wages of sub-station attendants and ticket agents,

Champaign.....2

Urbana.....2

Gibson.....1

Fisher.....1

Dewey.....1

Total, 7 men at \$50 per month, per year, \$ 3,600

Motormen, conductors, etc.,

10 X \$2.50 X 365.....\$ 9,125

Foremen, 1, linemen, 2, for line repair work,

1 at \$75 per month.....\$ 900

2 at \$60 per month.....\$ 1,440

Dispatcher, division superintendent, traffic manager, etc.,

Salaries.....\$ 4,000

Miscellaneous, taxes, etc.....\$ 3,000

TOTAL ANNUAL OPERATING EXPENSES.....\$ 36,565

OPERATING EXPENSES PER MILE OF TRACK.....\$ 892

TOTAL ANNUAL OPERATING EXPENSES.....\$ 36,565.

ANNUAL FIXED CHARGES.....\$ 115,345.

GROSS YEARLY EXPENDITURES.....\$ 151,910.

PER MILE OF TRACK.....\$ 3,720.





## SECTION VIII.

## C O N C L U S I O N S

		TOTAL	PER MILE OF TRACK
<u>GROSS EARNINGS PER YEAR (ESTIMATED)</u>	.....	\$162,727.00	---\$3,970.
" <u>EXPENDITURES PER YEAR</u> "	.....	\$151,910.00	---\$3,700.
<u>NET EARNINGS</u> "       "       "	.....	\$ 10,817.00	---\$ 364.

It is believed that the estimates of probable costs and probable earnings as given in this investigation are conservative. The final results indicate that an electrified extension of the Wabash Railroad such as is herein proposed would be feasible.



REFERENCE CONSULTED.

"American Railway Transportation."----Johnson.

"Electric Traction!"----Wilson and Lydall.

"Standard Handbook for Electrical Engineers."----M<sup>C</sup>-Graw.

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"Manual of Railroads."----Poor.

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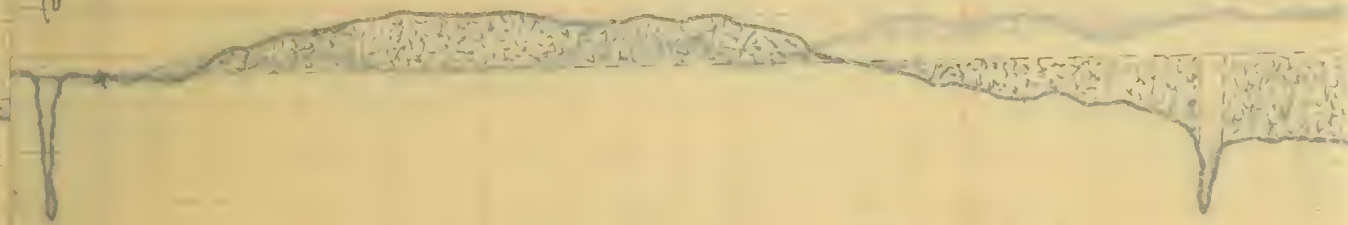
Yearbook of the Department of Agriculture.



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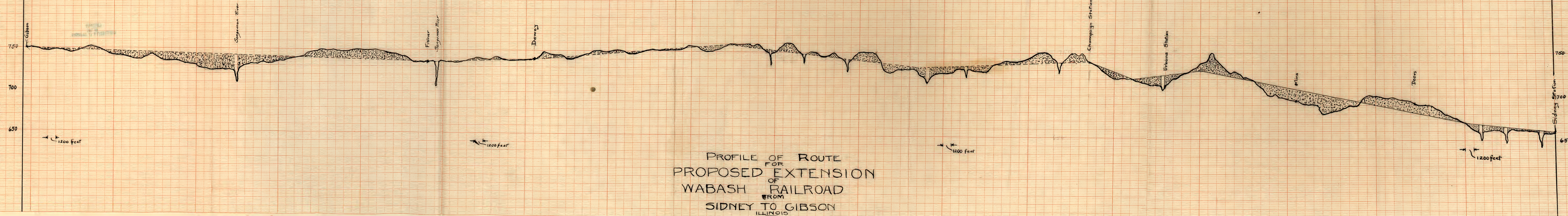
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Elevation Above Sea-Level — Feet



Elevation Above Sea-Level — Feet

PROFILE OF ROUTE  
FOR  
PROPOSED EXTENSION  
OF  
WABASH RAILROAD  
FROM  
SIDNEY TO GIBSON  
ILLINOIS

Figure 8.

"Perfect" PROFILE PAPER.  
PLATE A.

"Perfect" PROFILE PAPER.  
PLATE A.

"Perfect" PROFILE PAPER.  
PLATE A.















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